Rymer, Edwina

From: Dellinger, Philip
Sent: Tuesday, April 21, 2015 12:02 PM
To: R6 6WQ-SG;Brown, Jamesr;Gillespie, David
Subject: FW: DMN: Azle earthquakes likely caused by oil and gas operations, study says

FYI

From: Casso, Ruben
Sent: Tuesday, April 21, 2015 11:01 AM
To: Lawrence, Rob; Dellinger, Philip
Subject: DMN: Azle earthquakes likely caused by oil and gas operations, study says

Azle earthquakes likely caused by oil and gas operations, study says

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Tom Fox/Staff Photographer

A pickup passes a ranch entrance outside of Reno in rural Parker County. Oil and gas operations are the most likely cause of dozens of earthquakes that began rattling the North Texas towns of Azle and Reno in November 2013, a group of SMU scientists says.

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Staff Writer

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Oil and gas operations are the most likely cause of dozens of earthquakes that began rattling the North Texas towns of Azle and Reno in November 2013, a group of scientists has concluded.

The study, led by researchers at SMU and published Tuesday in the journal *Nature Communications*, presents some of the most conclusive evidence yet that humans are shifting faults below Dallas-Fort Worth that have not budged in hundreds of millions of years.

While experts have not yet determined what's causing the shaking in Dallas and Irving, the new paper previews aspects of that study and includes suggestions that will help speed research.

"It's certainly one of the best cases in the literature," said Art McGarr of the U.S. Geological Survey's Earthquake Hazards Program in Menlo Park, Calif.

The new findings contradict statements by the Railroad Commission of Texas that there are no definitive links between oil and gas activity and earthquakes in the state.

Shown an embargoed version of the paper, the commission's staff seismologist Craig Pearson wrote in a statement that "the study raises many questions with regard to its methodology, the information used and conclusions it reaches." But he declined to answer specific questions before meeting with the paper's authors. The Railroad Commission regulates the oil and gas industry.

The Azle study is the result of a yearlong collaboration involving 11 researchers at SMU, the University of Texas at Austin, and the U.S. Geological Survey and was reviewed by independent experts before publication.

The scientists zeroed in on an unusual mechanism behind the quakes: workers pushing liquid into the ground on one side of a fault and sucking gas and groundwater from the other side of the fault.

"The combination of these activities seems to have triggered the earthquakes, and that was a real surprise to us," said Matthew Hornbach, a geophysicist at SMU and a lead author of the paper.

Injecting fluids into the ground or extracting them has long been known to cause quakes, but rarely — if ever — have the two been caught acting in concert.

The geology of each region is unique, however, so these mechanisms may not be at work elsewhere.

The findings come at a time of heightened debate over oil and gas regulations in Texas. The state Legislature is considering bills that would curtail local governments' ability to impose fracking bans. Lawmakers are also weighing proposals for increased earthquake research and monitoring.

The paper's authors call for additional measures: closer monitoring of oil and gas wells and improved access to geologic information held by oil and gas companies.

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Wells still in operation

The Azle and Reno earthquakes culminated in two magnitude 3.6 tremors in November and December 2013 but have since dissipated, said Heather DeShon, an SMU seismologist who co-led the new study.

All four wells continue to operate, though both wastewater wells have reduced the volume of liquid they pump into the ground, according to Railroad Commission records last updated in September 2014.

The earthquakes mark the third set of North Texas tremors to be linked with oil and gas activity.

In 2008 and 2009, dozens of small tremors struck near Dallas/Fort Worth International Airport; in 2009 and 2010, more than 50 quakes shook Cleburne. Researchers are still investigating the cause of the recent, widely felt earthquakes in Irving and Dallas.

Before 2008, North Texas had experienced only two recorded earthquakes, both believed to be natural; the Azle and Reno area had experienced none. Since then, North Texas has logged more than 150 quakes of significant magnitude. The uptick is part of a dramatic increase in seismicity in central U.S. states, including Texas, Oklahoma, Arkansas, Colorado and Ohio.

The U.S. Geological Survey has blamed the rising rates largely on wastewater wells. The agency is expected to issue a report this week warning of a heightened hazard from earthquakes in Texas and other central states.

The Azle study is one of the most in-depth investigations of a Texas earthquake swarm. While earlier reports have linked quakes with wastewater wells based largely on timing and proximity, Hornbach and his colleagues sought to gain a clearer understanding of what was happening along the faults.

From previous studies, they knew it would take only a tiny amount of pressure to activate the faults, which are already stressed from the natural movement of tectonic plates.

“You’re just talking about kicking a system into motion,” said DeShon.

Ruling out drought

Still, they were able to rule out several causes for the quakes, including drought. They concluded that a 7-foot drop in water levels at nearby Eagle Mountain Lake translated to pressure changes below ground that were far too weak to affect the faults, which lie between 1 and 5 miles underground.

The seismologists also discounted natural shifts in tectonic plates as possible earthquake triggers. The two faults they mapped in Reno do not reach the surface, which suggests the faults have been dormant for more than 300 million years.

Still, they couldn't completely rule out that this was a randomly occurring swarm and wrote that it was "possible, but unlikely" that the earthquakes were natural in origin.

The team then gathered data on area wells, and here they found a smoking gun.

After analyzing data provided by the Railroad Commission and oil and gas companies, the scientists found that two wastewater wells near the site were generating the highest pressures close to the faults.

One, operated by XTO, a subsidiary of ExxonMobil, is located within about one mile of the earthquake epicenters, according to a locator map included in the study. Workers injected around 508 million gallons of wastewater into it from June 2009, when it opened, through September 2013, just before the earthquakes started. That's the equivalent of 890 Olympic-sized swimming pools.

The other well, operated by EnerVest, is located about 2 miles from tremor epicenters and buried around 123 million gallons of fluid from October 2010 through September 2013.

The team also found that two gas wells located almost directly above the earthquake swarm brought to the surface large volumes of groundwater, which further destabilized the surrounding rocks.

The underground pressure changes associated with the wells were tens to hundreds of times larger than those associated with the effects of the drought.

When Hornbach and his colleagues estimated how pressure from the wells built up along the faults from 2009 to 2013, they found that the buildup synced with the timing of the quakes.

Future prognosis

Will earthquakes return to Azle and Reno?

"That's the big question," said Brian Stump, an SMU seismologist who co-authored the study.

McGarr of the USGS, who was not involved in the research, said that the longer wastewater injections continue unabated, the greater the likelihood that earthquakes will spread across a wider area and grow stronger.

Cliff Frohlich, a seismologist at UT-Austin who is a co-author of the Azle study, said nothing in North Texas' history points to a risk of damaging quakes, though he can't rule them out.

"The kinds of quakes you've been having up there are not serious, and I would be very surprised if a quake greater than magnitude 4 would occur," he said.

In the paper, the scientists call for several measures that would lower the risk of man-made quakes. "We want to try to be more proactive, rather than reactive," said Hornbach.

One suggestion is improved information sharing among regulators, researchers and oil and gas companies.

More data needed

Companies such as Exxon and XTO readily provided the scientists with information they requested, including fault locations, but the process could be faster and more efficient, according to the scientists.

“We’re lucky that companies have been willing to work with us,” said Hornbach. “They have gone far above the call of duty. But we frankly still need a lot more data, and there are currently no regulations that require that data to be easily accessible.”

Detecting small earthquakes that might herald larger ones is another approach that the scientists recommend.

Texas currently has 16 permanent seismic stations that can record earthquakes down to a magnitude of 3, which experts say is not nearly sensitive enough. The denser the network, the greater its level of precision.

Texas does have a seismic network in the works. Legislation on the table in Austin would provide $2.5 million in funding for TexNet, which includes an additional 22 permanent seismic monitors, plus 36 portable stations that could be deployed to areas experiencing new tremors.

Stump calls TexNet 'a good start' but adds that it's still unclear how many of those stations would end up in North Texas and whether the funding would provide for additional manpower to read and interpret the new quake data.

Detecting quakes down to a magnitude of 2 is important because small quakes can help predict larger ones and, if the tremors are man-made, they can alert regulators and oil and gas companies to the need to slow or suspend wastewater injections.

Finally, the authors recommend that companies be required to regularly report how much groundwater their oil and gas wells bring to the surface. As the Azle study shows, removing water from the earth can be as troublesome as injecting it.

Follow Anna Kuchment on Twitter at @akuchment.

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MISSED WARNINGS

Scientists have understood for decades that injecting wastewater into the ground at high pressures can cause earthquakes. They have also known that monitoring the underground pressure near injection sites could reduce the risk of quakes. Some signs:

1962-1981: Rocky Mountain Arsenal in Colorado. The disposal of hazardous waste from this defense plant into a deep well causes earthquakes that continue for years after injections stop.

1968: Dallas. In a volume published by the American Association of Petroleum Geologists, a Dallas-based oil consultant writes that it’s essential to closely observe pressures near injection wells.

1969-1973: Rangely Oil Field in Colorado. Inspired by the Rocky Mountain Arsenal example, the U.S. Geological Survey launches an experiment to show how man-made quakes can be controlled. The agency finds that, if workers monitor the pressure near injection wells and adjust the rate and volume of injections accordingly, they can better manage earthquake risk.

2014: Oklahoma. A study in the journal *Science* links a sharp increase in Oklahoma earthquakes to "massive wastewater injection." The author, Cornell University's Katie Keranen, writes that regular measurement of subsurface pressure could provide an early warning about earthquake risk but notes that such data "are rarely accessible."

2014: Austin. In public comments to the Railroad Commission on its proposed rules for disposal wells, researchers from Southern Methodist University recommend that the commission require companies to measure and report subsurface pressures near injection wells annually. The commission replies that the change is not warranted.

2015: Azle and Reno, Texas. Scientists find that elevated underground pressure near wastewater wells probably caused a series of earthquakes near Fort Worth.

SOURCE: *Dallas Morning News* research

A perfect combination

Scientists believe that four wells were the primary cause of the earthquakes in Azle and Reno. Two are wastewater injection wells, where companies dispose of water, chemicals and sand used in hydraulic fracturing; and two are natural gas wells.

A. Workers extract gas and salt water from a production well, causing a decrease in underground pressure.

B. On the other side of the fault, workers at a different well inject wastewater into the ground, causing an overall pressure increase.

C. The pressure changes cause nearby faults to slip, triggering earthquakes.

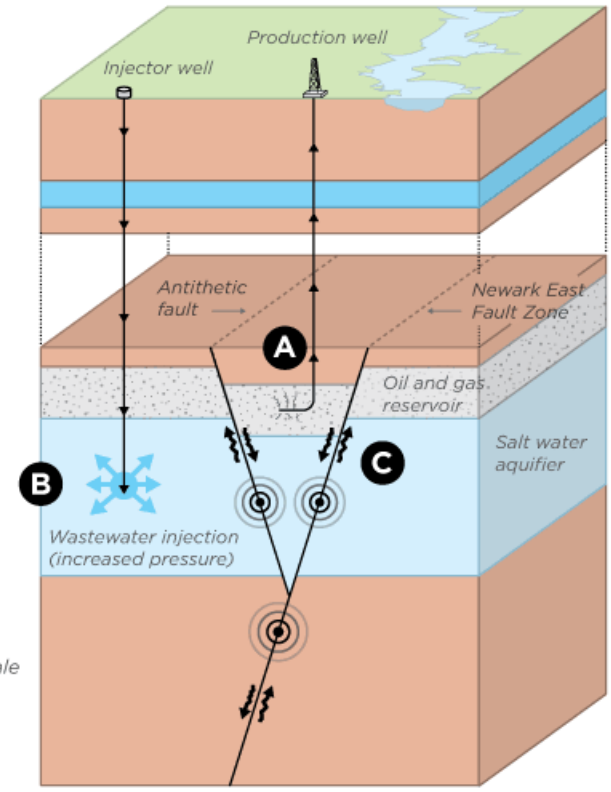

Diagram not to scale

SOURCE: *Hornbach et al., Nature Communications 2015*

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